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Short term Load Forecasting using Resource Allocation based Artificial Neural Network

Rashmi M N[1], Soumya L M[2]
[1]Senior Scale Lecturer, Electrical and Electronics Engineering, Government Polytechnic Mirle, Mysore, Karnataka, India.
[2]Senior Scale Lecturer, Electrical and Electronics Engineering, Government Polytechnic Nagamangala, Mandya, Karnataka, India.
Email ID: *rmn208@gmail.com[1], soumya.mamata@gmail.com[2]*

Abstract
Load forecasts are extremely important for energy suppliers, financial institutions, and other participants in electric energy generation, transmission, distribution, and markets. Load forecasting helps an electric utility to make important decisions including decisions on purchasing and generating electric power, load switching, and infrastructure development. The use of artificial neural networks (ANN or simply NN) has been a widely studied electric load forecasting technique. These networks are essentially non-linear circuits that have the demonstrated capability to do non-linear curve fitting. The use of artificial neural network has received increased attention in recent years, because of its usefulness in reducing the needs for complex mathematical models in problem solving. In this paper we use a new approach for load forecasting using Radial-Basis function networks (RBF). These networks being the members of a class of neural network models address the problem of curve fitting that is approximation in high dimensional space that provides a best fit to the training data, measured by pre-selected statistical criteria. Because of this non-linear nature of these models, the behavior of the load prediction system can be captured in a compact, robust, and more natural representation. In the present work, resource allocation network (RAN), a type of RBF network with one hidden layer has been used as load forecasting model.
Keywords: *Load Forecasting, Short Term, Artificial Neural Networks (ANN), Resource Allocation Network (RAN), Radial-Basis Function Networks (RBF)*

1. Introduction
Artificial Neural network is an information processing method that is inspired by the way of the biological nervous systems. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. The use of artificial neural networks (ANN or simply NN) has been a widely studied electric load forecasting technique since years. Neural networks are essentially non-linear curve fitting. The outputs of an artificial neural network are some linear or nonlinear mathematical function of its inputs. The inputs may be the outputs of other network elements as well as actual network inputs. In practice network elements are arranged in a relatively small number of connected layers of elements between network inputs and outputs. Feedback paths are sometimes used [1].

1.1. Types of Load Forecasting
Load forecasts can be divided into three categories: Short-term forecasts, Medium-term forecasts, Long-term forecasts. Short-term forecasts, which are usually from one hour to one week, for the allocation of spinning reserve it would be necessary to predict the load demand at least half an hour to a few hours ahead. Load forecasts with such lead times are referred as short time forecasts. Medium- term forecasts which are usually from a week to a year. Preparing to meet the load at a height of the winter or summer season may require a load forecast to be

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made a few days to few weeks in advance. Forecasts with such lead times constitute medium term load forecasts. Long-term forecasts which are longer than a year. To plan the growth of generation capacity, it would be necessary to make a long-term load prediction, which may involve a lead-time of a few months to few years [2].

1.2. Load Forecasting Techniques

Over the last few decades a number of forecasting methods have been developed, which include the so-called similar day approach, various regression models, time series, neural networks, expert systems, fuzzy logic, and statistical learning algorithms; are used for short-term forecasting. These forecasting data give a rough prediction of the load at a given season, day of the week and time of the day. These models cannot adapt easily to rapid changes of the load variation pattern, they have deficiencies, especially in geographically diverse areas and with abrupt changes in environmental variables. The Artificial Neural Networks (ANN) technology has been proposed as a substitute for statistical approaches for forecasting problems. It is more promise than any other system because they do not rely on human experience or predefined mathematical relationships between model inputs and outputs. Rather, they attempt to form natural links between inputs and outputs through a process of self-learning and extract implicit non-linear relationships from historical data. The change in the load is not only influenced by external weather and time variables but is also dependent on the past and current load state. Because of this non-linear nature of these models, the behaviour of the load prediction system can be captured in a compact, robust and more natural representation. In our paper work we have implemented a Radial Basis function (RBF) neural network called as Resource Allocation Network (RAN) which is an incremental learning neural network, that provides a best fit to the training data, measured by pre-selected statistical criteria [3].

1.3. Short Term Load Forecasting Within the Energy Management System (EMS)

The manual forecasting previously performed by the system dispatchers has been replaced by Short-term load forecasting software packages in modern energy management system (EMS). The major components of a Short-term load forecasting (STLF) system are the STLF model, the data sources, and the man-machine interface (MMI). The STLF model implements the system load representation and the STLF algorithms. The data sources are the historical load and weather databases, the parameter database, the manually entered database entered by the dispatchers, and the real-time data obtained from the Automatic generation control (AGC) functions of the EMS and the data link to the weather forecasting service. Figure 1 illustrates the data inputs to the STLF function. The manually entered data may include weather updates, load forecast parameter data or execution commands. In general, the STLF models use integrated load (MWh) data. The telemetered measurements in the real time database are used by the AGC to determine the "measured" loads which are typically integrated (and consequently smoothed) before they are used by the STLF model. The outputs of the STLF are provided to the dispatcher workstations and the other EMS functions that require the load forecasts the timeliness and accuracy of short-term load forecasts have significant effects on power system operations and production costs. Thus, by reducing the forecast error, reserve levels may be reduced without affecting the reliability of the system. In this way, the operating costs are reduced [4].

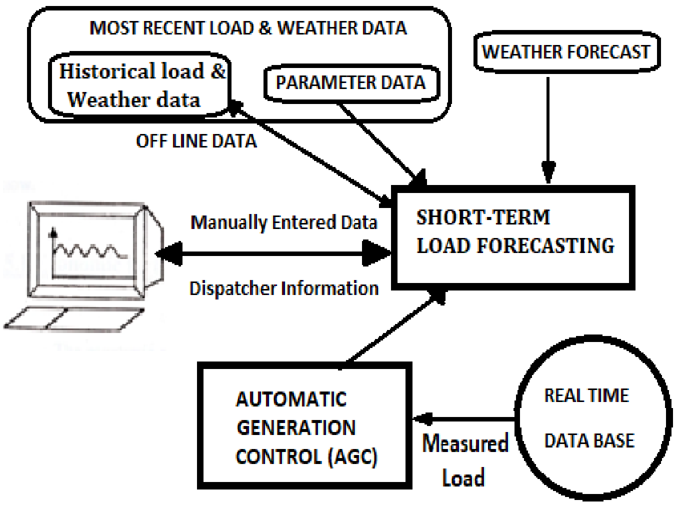

Figure 1 Input Data for Short Term Load Forecasting

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1.4. Why Neural Networks

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. Learning in the neural network is the process of presenting the input patterns repeatedly until the networks learn them completely.

1.5. RBF Network Architecture

RBF network architecture consists of three layers (refer figure 2): Input layer: This layer passes the example vectors to the next layers. Hidden layer: This layer applies a non-linear transformation function to the inputs and expands them in the usually very high-dimensional hidden space. Output layer: This layer applies a linear transformation to the given vector. RBF networks are designed to perform non-linear mappings from the input space to the hidden space, and next a linear mapping from the hidden space to the output space. Here input neurons are linear and pass the inputs along to hidden neurons without any transformation. The input vector X thus feeds forward to each hidden neuron. There is one hidden neuron for each basis function, and thus there are few of them. After computing the signal, hidden nodes pass on these signals through weighted pathways to the linear output neurons, which sum these up and generate an output signals. Such a network is called a radial basis function network. The RBF neural network called Resource Allocation Network (RAN) is considered. This network is fast learning based on both memorization and gradient descent. The neural network considered here is an auto-configuring neural network, which develops it architecture based on the novelty of the input patterns [5].

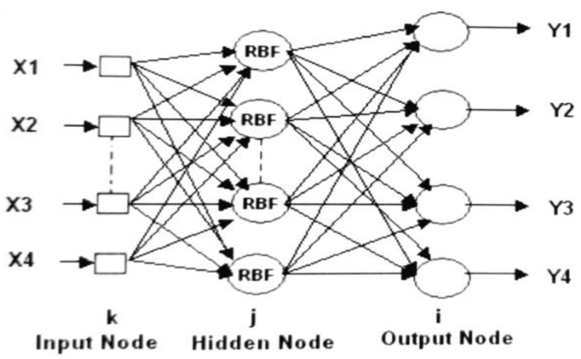

Figure 2 RAN Architecture

1.6. RAN Learning Algorithm

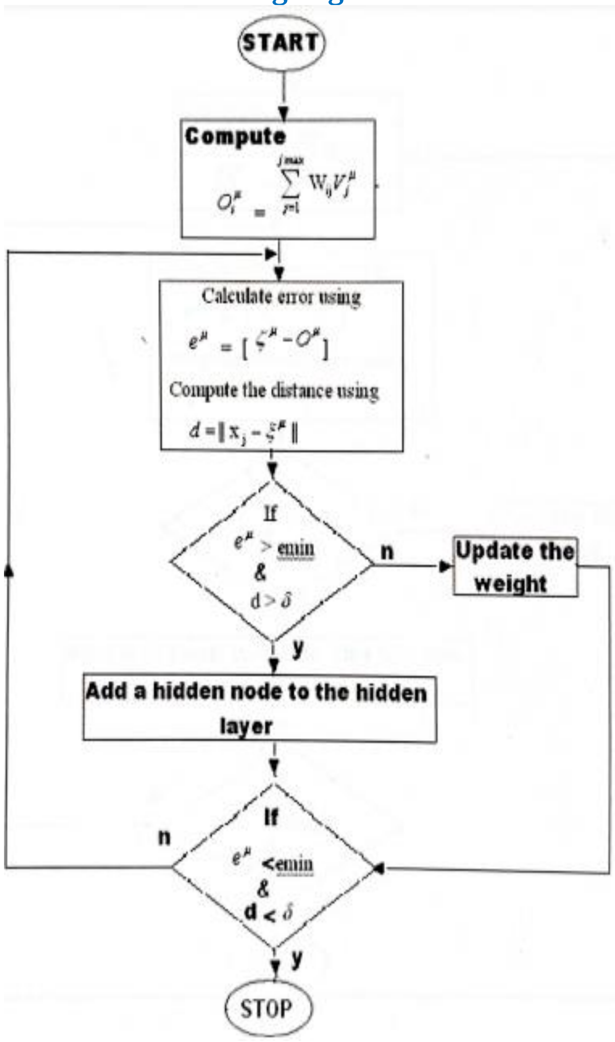

Figure 3 Flow Chart of The RAN Algorithm

The learning in a RAN begins with no hidden nodes. The network creates one node when the first pattern is presented to it. On subsequent presentation of patterns, the network checks for two criteria. First it verifies the nearness of the incoming pattern with respect to the hidden nodes. Secondly, it checks the closeness of output error with respect to the minimum predefined error tolerance. If these conditions are not satisfied the algorithm adds a node otherwise it performs gradient descent in the weight space. The RAN algorithm is ideal for classification application because, the algorithm can learn large database of patterns having high dimensions in relatively less epochs while evolving its architecture [6]. Figure 3 shows the flow chart of the RAN algorithm.

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1.7. System Studied and Results

In the present work, Week ahead forecasting is carried out for benchmark data set obtained from an Electric Supply Company's Load data available on World Wide Web (WWW). Using historical data and daily temperature data, load forecasting is done by using an incremental learning neural network called Resource Allocation Network (RAN). The First Phase is to train the network with known set of input patterns and desired output patterns. The data set has been normalized so that the input load data falls in the range 0 to 1. A training set consisting of load data for two weeks is used for training the network. During training fixing the network simulation parameters k, η and ζ is very important to get optimal network architecture. The trained network is tested by using test data set. Figure 4, The output of the neural network is as shown below in the graph of forecasted load [7].

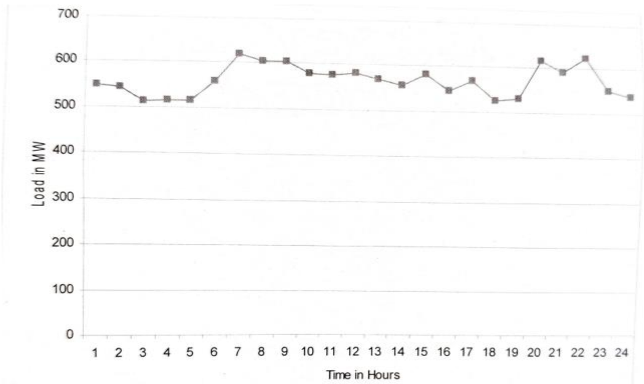

Figure 4 Graph of forecasted Load

Conclusion

Neural networks do not perform miracles. But if used sensibly they can produce some amazing results". Presently in power stations we are using statistical methods to forecast the load but accurate results are not obtained. If we replace statistical methods by neural networks, we can achieve better results. Neural networks also contribute to other areas of research such as neurology and psychology [8]. They are regularly used to model parts of living organisms and to investigate the internal mechanisms of the brain. Perhaps the most exciting aspect of neural networks is the possibility that someday 'conscious' networks might be produced [9].

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